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THE OBJECTIVE ASSESSMENT OF THE FAITHFULNESS OF COLOUR REPRODUCTION IN COLOUR TRANSPARENCIES

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INTRODUCTION

In recent years naturalists have come to use colour photography extensively in order to record the natural colour of biological, geological and archaeological material. Few, however, make any provision for an objective assessment of the faithfulness of the colours preserved in their photographic records. Here, a simple method is described which will allow such an assessment to be made.

The photographic material discussed in this paper is Kodachrome; this does not imply that this material is more subject to variation in colour than other film; it has simply been chosen for particular reference because it appears to be the colour-sensitive photographic material most used by Western Australian naturalists. The colours of the positive emulsion layers which are mentioned in this paper do not necessarily occur in films other than Kodachrome; in other films, different coloured dyes may be used and colour sensitive elements may be differently distributed. However, the problems facing the interpreter and the recorder remain the same.

THE FAITHFULNESS OF COLOUR IN PHOTOGRAPHIC REPRODUCTION

The average photographer taking coloured pictures does little more than aim at achieving a pleasing result and he does not worry about a lack of faithfulness in his reproductions and his inability to recognize it in them. The scientific worker, on the other hand, must achieve accurate colour in his record, or the purpose of making it is lost. If this cannot be done, he must at least be able to check the amount that it deviates from accuracy and the way in which it does this.

Most naturalists make some attempt to achieve what appear to be reasonably natural colours in their positive images; they take care to ensure that constant amounts of light are admitted to the film upon exposure, they try to keep the brightness range of the subject within the limits set by the particular film in use, they use the correct type of film (or a compensating filter) to reduce the effects of abnormal illumination of the subject either by "visible" or by ultra-violet light, and whenever possible they keep the film

under optimum storage conditions, but they make no provision which allows them to confirm that they have been successful in their attempts at accuracy.

For the benefit of those who are puzzled about the causes of inaccuracies in colour reproduction, the commonest of these are described below.

1. **Exposure:** The colours of the positive result will appear to vary in saturation and brightness in accordance with the amount of light admitted during exposure, thus an under-exposed blue sky will appear to be a much "deeper" blue than it was at the time of photography, while the same sky taken at the same time and over-exposed, is almost white.

2. **Lighting conditions:** The colour of the light which illuminates the subject will be recorded in the image. For example, photographs taken in the yellow light of early morning, or in the evening, will often be excessively yellow. "Tungsten" light has a similar effect. Under certain conditions, large amounts of ultra-violet light may be present. To the photographer, this ultra-violet light is not visible but film is sensitive to it and, in extreme examples, photographic images of white objects may be quite blue. The photographer most commonly meets such conditions at great heights. Blue light is also commonly encountered in shadows and in snow scenes; here it is probably due to reflected sky light (see Evans, Hanson and Brewer, 1953, p. 171).

3. **Instability of colour material in light or in time:** No reputable manufacturer of colour film guarantees the stability of the dyes in the emulsion of his colour film over long periods of time. Kodak Ltd. state "The dyes used in 'Kodachrome' Film, like other dyes, may in time change. This film, therefore, will not be replaced or otherwise warranted against any change in colour. In display or projection 'Kodachrome' transparencies should not be left illuminated for an undue length of time, otherwise fading of the dyes may result."

Uniform overall fading as a result of dye instability affects the saturation and brightness of the colours which are seen by the viewer of the photographic record and this is serious enough, but in addition to this, the image which is produced by the filtering effect of different combinations of different dyes may alter in colour since the separate dyes may fade at slightly different rates. Since most colours in the image are the result of the subtractive mixture of more than one dye (see Kodak, 1950, pp. 11-13 for an excellent and clear account of this), much of the image may actually change in hue as well as in saturation and brightness.

4. **Instability of unprocessed material:** Out-of-date film, or film kept under abnormal conditions of humidity and temperature, may behave differently upon exposure as compared with film kept under ideal conditions. The effect of abnormal storage may be abnormal colours in the positive image. Some very slight colour variations are unavoidable in manufacturing but variations as a result of these are much smaller than those due to poor storage and other causes.

5. **Physical characteristics of dyes:** The dyes used in colour photography are not perfect in that they do not transmit light

freely. They all absorb some of the light that they should ideally transmit. Further, they do not absorb identical quantities with the result that it is not possible to obtain, with the dyes at present available to manufacturers, *simultaneous* accurate reproduction of all colours. In practice, the properties of the dye-layers are balanced to give the most *pleasing* results and the departures need not readily matter providing they can be recognized (see Kodak, 1950, p. 36-39).

KODACHROME FILM AND THE COLOUR-CONTROL CARD

The recording process used in Kodachrome is a reversal process in which the positive colours seen in the image result from the subtractive mixture of three transparent layers of dyes in the developed emulsion (Kodak, 1950, pp. 31-35). When the transparency is viewed, light passes through these coloured layers and the filtered light is "seen" by the viewer. The colours of the dye-layers which act as filters in positive Kodachrome transpareneies are yellow, "cyan" (blue-green), and magenta. If a saturated cyan-coloured subject is photographed, neither of the other two layers in the emulsion is coloured in the positive transparency while the cyan dye-layer is heavily coloured.

Thus a simple method of objective assessment of faithfulness of colour reproduction by Kodachrome film would be one which would allow the photo-sensitive reaction of each dye-layer in the emulsion to be examined independently. Inaccurate colour balance in the transparency due to abnormal behaviour of any dye layer resulting from incorrect illumination, or other reason, could thus be simply detected and the appropriate mental compensation made during interpretation.

*Additional copies of the plate may be obtained from the Western Australian Museum.

A simple colour-control card can be made (see accompanying plate*) to enable the behaviour of the individual dye-layers to be objectively assessed. Three coloured squares which match the saturated colours of the individual dye-layers are mounted together on a card. In addition to these, a white square is used to give a fourth "colour" control. A centimetre scale may also be conveniently included on the card.

THE USE OF THE COLOUR-CONTROL CARD

The colour-control card is included in each photograph for which colour assessment is desired. After the transparency is returned from processing, and at any time thereafter, the colours of the actual card are matched with those of the viewed image of it. It is important to note that the transparency should be viewed by filtered tungsten light, while the colour-control card must be viewed by natural daylight; in practice it is found that it is simplest to use a table viewer to examine the transparency, and the colour-control card can be held alongside it in daylight. Comparison of the coloured sections and their images allows the behaviour of the three dye-layers to be examined while the presence of excess ultra-violet or coloured light can be most simply detected by any deviation from "whiteness" in the white square.

COLOUR-CONTROL CARD

One major precaution must be taken in the use of the colour-control card. The dyes used in the card will probably themselves fade in bright light and in time. However, unlike biological records, these cards can be replaced. The user should merely protect his card as far as possible and compare it at intervals with a fresh card to ensure that the colours have remained unaltered.

AUTHOR'S NOTE

Naturalists may encounter some difficulty in obtaining supplies of paper of the correct colours. Kodak Ltd. of London, manufacture sets of colour separation guides which contain a strip of "colour patches" which include the three colours cyan, magenta and yellow. Unfortunately, six other coloured squares are included in the patches and for the purposes outlined in the paper the strip is unnecessarily bulky. Further, the colour separation guides include register marks and a grey scale which makes the set unnecessarily expensive. However, it appears that the separation guide remains the most satisfactory source of standard coloured squares for use in the technique I have described.

ACKNOWLEDGMENTS

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ANNOTATED FLORA OF ROTTNEST ISLAND, WESTERN AUSTRALIA

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Since February 1955 the writer has been working on various aspects of nutrition in the Quokkas *(Setonix brachyurus)* of Rottnest Island. A large part of the field work in the first two years was spent in examining the vegetation for evidence of Quokka grazing. Field-notes were transferred to cards, including one for each plant species, on which were recorded the date and locality of observations, the intensity of grazing and the growth stage of the plant. Although these data were gathered primarily for an understanding of the Quokka's economy, they also provide a basis for a flora of Rottnest.

In the following systematic list, brief notes have been extracted from the cards concerning the habit, distribution, abundance, palatability, etc., of each species. Exotic species are prefixed with an asterisk.